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Document Listing

Document	Image pages	Text pages	Error pages
US 3742498 A	0	2	0
Total	0	2	0

CLIPPEDIMAGE= US003742498A
PUB-NO: US003742498A
DOCUMENT-IDENTIFIER: US 3742498 A
TITLE: SYNCHRONIZATION AND POSITION LOCATION SYSTEM

PUBN-DATE: June 26, 1973

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APPL-NO: US3742498D
APPL-DATE: May 6, 1970

PRIORITY-DATA: US03504970A (May 6, 1970)
INT-CL_(IPC): H04B007/20
EUR-CL_(EPC): G01S013/82; H04B007/212

ABSTRACT:
A master station and N slave stations include synchronization equipment to enable each of the stations to have access to a common repeater in a different one of M time slots of a TDM format at the repeater, there being motion between the master and slave stations and the repeater. Each time slot is employed on a push-to-talk basis for N/M slave stations. The master station propagates a reference sync burst through the repeater. Each of the stations receive this master sync burst from the repeater. The master station adjusts the frequency of the timing signals therein to compensate for the doppler shift experienced in the propagation path from the master station to the repeater and each of the slave stations adjusts the frequency of the timing signals therein to compensate for the doppler shift experienced in the propagation path from each of the slave stations to the repeater so that the desired frequency of the timing signals is present at the repeater. The master station in

response to the received master sync adjusts its timing signals so that the signals propagated therefrom arrive in the proper time slot of the TDM format at the repeater. Each of the slave stations propagate a different low power level, psuedo noise code ranging signal through the repeater to the master station. The phase information of this ranging signal is detected in the master station, coded, and transmitted to the appropriate one of the slave stations. This phase information is responded to in the appropriate slave station to adjust the phase of its timing signals so that data bursts of each of the slave stations appear in the proper time slot of the TDM format at the repeater. The ground station responds to the phase of the received master reference signal and the phase information of the ranging signal to provide a measure of the satellite-to-slave station range at the ground station. In a single satellite system, the altitude of the slave stations and the rate of change or range, obtained from measuring the doppler of the carrier signal received at the associated slave station and is transmitted to the ground station in slow speed data channels provided during the synchronizing interval of each of the data bursts. These two bits of information together with the satellite-to-slave station range enables the ground station to locate the position of a particular slave station. In a two satellite system, the equipment for determining the satellite-to-slave station range is duplicated for cooperation with a second satellite so that the altitude of the slave station and the satellite-to-repeater range for both satellites enable the position location of a particular slave station at the ground station.

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Document Listing

Document	Image pages	Text pages	Error pages
US 3593138 A	0	19	0
Total	0	19	0

DOCUMENT-IDENTIFIER: US 3593138 A
TITLE: SATELLITE INTERLACE SYNCHRONIZATION SYSTEM

ISY:
1971

ABPL:
A master station and a plurality of slave stations include synchronization equipment to enable each of the stations to have access to a common repeater in a different time slot of a time division multiplex format at the repeater, there being motion between the stations and the repeater. The master station propagates a sync burst through the repeater. Each of the stations receives this sync burst from the repeater and adjusts the frequency of the timing signals therein to compensate for the doppler shift experienced in the propagation path from each of the stations to the repeater so that the desired frequency of the timing signals is present in the repeater. Each of the slave stations also propagates different low power level, psuedo noise code ranging signal through the repeater back to itself which is used to adjust the phase of the timing signals digitally and in an analog manner by means of a motor-driven phase shifter to account for the changing range between the repeater and each of the slave stations so that a data burst of each of the slave stations appears in the proper time slot of the time division multiplex format at the repeater.

BSPR:
This invention relates to communication systems and more particularly to communications systems wherein a plurality of stations gain access to and communicate through a common propagation media, such as a common repeater.

BSPR:

Multiple access communication systems have been utilized for many years to
achieve multiple access to long-distance telephone trunk systems. In addition,
this multiple access technique is applicable to other communication systems
including, but not necessarily restricted thereto, (1) supervisory control
systems to enable supervision, from a fixed common repeater, or from a central
station through the common repeater, of the activities of a plurality of mobile
stations, (2) remote control systems to enable control, from a fixed common
repeater, or from a central station through the common repeater, of various
responsive devices contained in a plurality of mobile stations, (3)
communication systems to establish, maintain and/or enable communication
between a fixed common repeater, or a communication center coupled to the fixed
common repeater, and a plurality of mobile stations, such as is necessary
between an airport control tower and a plurality of airliners, and between a
dispatcher communication center and a fleet of taxicabs, emergency vehicles and
cargo carrying trucks, and (4) a communication satellite system to enable a
plurality of fixed ground stations to utilize a common repeater carried by an
orbiting satellite.

BSPR:
In providing the multiple access for the various systems above set forth,
different techniques have been employed in the past. One such technique is the
so called random access technique to enable a plurality of stations to have
access to and communicate through a common repeater on an undefined basis,
namely, a random basis. Another such technique to permit achieving of multiple
access is in the employment of frequency division multiplex techniques wherein
each of the plurality of stations employs a different carrier signal and
wherein the common repeater has the bandwidth to handle all of the different

frequency carriers and the intelligence carried thereon. Still another technique enabling multiple access to a common repeater has been by the employment of time division multiplex techniques wherein each of the plurality of stations are assigned to, or are capable of selecting, a time slot in time division multiplex frame or format at the common repeater to thereby permit communication through the common repeater in a noninterferring relationship.

BSPR:
In multiple access systems employing time division multiplex techniques it is mandatory that there be a strict time synchronization so that each of the plurality of stations transmits its intelligence in a different one of a plurality of time slots of a time division multiplex format and be so confined to that time slot selected for a particular station that its communication will not interfere with communications of other stations in adjacent time slots of the format.

BSPR:
In time division multiplex multiple access systems, it has in the past been the practice for a common repeater to receive a number of independent carrier signals and by commutation equipment carried in the repeater interleave the independent carrier signals bit by bit in a continuous sequence. This arrangement requires considerable equipment in the repeater. If the repeater is mobile, such as in satellite communication systems and the like, there could result a weight problem for the vehicle carrying the repeater equipment and with respect to a satellite carrying the repeater equipment an increase in the cost of the launch vehicle to place the satellite in a desired orbit.

BSPR:
In a prior art time division multiplex multiple access system, such as

described in U.S. Pat. No. 3,320,611 and Belgium Pat. No. 669,318, there is described an arrangement enabling a reduction in the hardware required in the repeater and, hence, a reduction in the problem of providing a vehicle to carry this repeater. By removing the time division multiplex equipment from the repeater itself it is possible to use a simple clipper/amplifier or hard limiting repeater.

BSPR:
It has been found, in addition, that the pulse or bit-by-bit interleaving imposes considerable equipment problems in the plurality of stations requiring access to the common repeater. This complexity can be overcome, or at least materially reduced where the interleaving at the repeater is performed on bursts of pulses from each station.

BSPR:
Where there is relative movement between the common repeater and the plurality of stations, whether it is the repeater that is moving, or the stations that are moving, or both the repeater and stations moving relative to each other, it is necessary, where time division multiplex techniques for multiple access to the common repeater are employed, to provide in some manner the range information between the station considered and the common repeater on a continuous basis. In the above-cited prior art patents, this range information was obtained from a computer or like device contained in each of the plurality of stations which provide information of the relative location of and range between the common station and the considered one of the plurality of stations with the programming of the computer being based upon predicted relative movement between the common repeater and the considered station. The total inaccuracy of the range prediction with elementary equipment has been determined to be in the order of one microsecond. Hence, the

system timing
format was developed having a one microsecond guard band between transmission
from each station and the next adjacent station in the format. To realize
reasonable efficiency of utilization of the common repeater, each station burst
interval must be long in comparison to this guard band, hence, a burst length
of 125 microseconds was established. Thus, each station must have equipment to
store communication traffic for a short period of time and transmit this in a
125 microsecond burst. The repetition interval and, consequently, the required
storage time is the product of burst length and the number of simultaneous
users for which the multiple access system has been designed.

BSPR:
In a known prior art arrangement, the continuous range information is provided
by means of a pseudo noise code signal transmitted from each of the stations
through the repeater back to itself with the equipment responding to this
pseudo noise code signal to adjust the timing signals to account for changing
range between the station and the repeater with the control of the timing
signals being performed in a digital manner.

BSPR:
Another object of the present invention is to provide a synchronizing system
for a time division multiplex multiple access system wherein the
synchronization equipment is located in each of a plurality of slave stations
and a master station with the common repeater being of the hard limiter
repeater.

BSPR:
Still another object of this invention is to provide a synchronizing system for
a time division multiplex multiple access system that does not require knowing
or predicting the position of the considered station and the common repeater
and the range between the considered station and the common repeater.

BSPR:
Still a further object of this invention is to provide a combined digital and analog synchronizing system for a time division multiplex multiple access system incorporating therein an arrangement to compensate for the doppler shift of the transmission path from the considered station to the common repeater.

BSPR:
A feature of this invention is the provision of a synchronization system to control signals transmitted from each of a master station and a plurality of slave stations to be propagated through a common repeater in a different one of a plurality of time slots of time division multiplex format at the repeater, the stations and the repeater having relative motion therebetween, comprising first means disposed in the master station to transmit a sync burst through the repeater in one of the time slots; second means disposed in each of the slave stations responsive to the sync burst from the repeater to control the production of timing signals employed to control the time of transmission of the transmitted signals from the associated one of the slave stations; third means disposed in each of the slave stations to transmit a ranging signal through the repeater in its associated one of the time slots; and combined digital and analog means disposed in each of the slave stations coupled to the second means responsive to the ranging signal received from the repeater to adjust the phase of the timing signals so that the time of transmission of the transmitted signals from the associated one of the slave stations is such that the transmitted signals occur in the proper one of the time slots at the repeater.

BSPR:
Another feature of this invention is the provision of means in each of the

above-mentioned first means and second means to adjust the frequency of the
synch burst and the frequency of the transmitted signal to compensate for the
doppler effect in the transmission path from the master station to the repeater
and in the transmission path from the associated one of the slave stations to
the repeater to provide the sync burst and the transmitted signal received at
the repeater with the desired frequency.

DRPR:
FIG. 2 is a timing diagram illustrating the frame format of the time division
multiplex frame at the common repeater of FIG. 1;

DEPR:
Referring to FIG. 1, there is illustrated therein a block diagram of a
generalized multiple access communication system wherein a plurality of
stations, which for purposes of illustration and explanation are assumed to be
master station 11 and slave stations 1 to 10, are shown in two-way
communication with common repeater 12. As indicated, common repeater 12 can be
fixed or mobile and each of stations 1 through 11 can be fixed or mobile. It
should be noted that the multiple access system of FIG. 1 can be used in any of
the applications outlined hereinabove under the heading "Background of the
Invention." While this multiple access system can employ frequency division
multiplex or random access techniques for multiple access, in accordance with
the principles of this invention it is intended that multiple access be
provided to repeater 12 by employing time division multiplex techniques.

DEPR:
In the multiple access communication system each of the stations 1 through 11
transmits bursts which are timed to arrive at the repeater 12 on a
noninterferring relation relative to bursts from other stations. The phasing
of the transmitted signals must then be adjusted to compensate

for the
difference in range between repeater 12 and the various stations
1 to 11.
Where there is motion between repeater 12 and stations 1 and 11,
the range is
continuously changing and the continuous phase adjustment results
in a
frequency offset, namely, the doppler effect which is
proportional to the rate
of change of range.

DEPR:
The time division multiplex format for the system of this
invention is shown in
curve C, FIG. 2, and is based on the real time transmission of
information. A
single sync burst, as illustrated in Curve A, FIG. 2, is
transmitted from the
master station and 10 data bursts of 10 microseconds duration are
transmitted
from slave stations 1 through 10. Curve B, FIG. 2, illustrates
the data bursts
transmitted from slave station 1. As illustrated in Curve C,
FIG. 2, the frame
format at repeater 12 includes the sync burst and data bursts
each having a 10
microsecond duration with a 1.25 microsecond guard time
therebetween resulting
in a frame period of 123.75 microseconds.

DEPR:
Synchronization is maintained by doppler tracking in which master
station 11
tracks the doppler actively and slave stations 1 to 10 track the
doppler
passively. The sync burst carrier is modulated by 800 kHz.
(kilohertz) which
is harmonically related to the frame rate and is used for all
time divisions in
the format. Master station 11 transmits the sync burst
consisting of 800 kHz.
minus its own doppler and receives the sync burst as 800 kHz.
plus its own
doppler. The transmitted frequency is adjusted so that sum of
the transmitted
and received frequencies is a constant. This method of doppler
tracking
assures that the sync signal at the repeater 12 is true 800 kHz.

DEPR:
A slave station receives the pulsed sync burst from master

station 11 via repeater 12. Since the signal was a true 800 kHz. at repeater 12, it will be received with the true doppler of the considered slave station. The slave station uses this signal to preset its transmit frame rate by a technique identical to that used by master station 11 for doppler tracking. The slave stations used in pseudo noise code ranging technique to determine the correct initial phase for their transmit format.

DEPR:
The equipment employed in each of the master station 11 and slave stations 1 through 10 is illustrated in block diagram form in FIGS. 4, 5, 6, 7, 8 and 9, when arranged as illustrated in FIG. 3. By proper manipulation of switches A4S59, A4S53, A4S56, A4S46, and A4S43 (FIG. 9), it is possible to have the equipment operate as a master station wherein the pseudo noise and subcarrier operation is inhibited and the sync burst and carrier operation are activated. To provide operation as a slave station, the sync burst modulation and carrier are inhibited and the pseudo noise modulation and subcarrier are activated.

DEPR:
The transmit clock generator, identified as transmit clock phase locked loop 19, contains the doppler compensation circuit which adjusts the transmitted clock frequency to maintain the repeater clock frequencies at exactly 800 kHz. independent of first order doppler effects. This is implemented by passing the receive and transmit clock frequencies through a mixer arrangement which extracts their sum frequency, then compares the sum frequency with a 1600 kHz. reference frequency and adjusts the phase of the voltage controlled oscillator 18 in such a manner to keep the sum exactly equal to 1600 kHz.

DEPR:
Letting fR and fT denote the receive and transmit frequencies, respectively,

this may be written as fR+fT=1600. Assuming that fT is decreased by the doppler coefficient d in transmission, the repeater frequency will be frep. = fT-d. Ignoring second order effects, the receive frequency will be equal to the repeater frequency reduced by d, namely, fR = frep. - d. Substituting the last two equations into the first equation will demonstrate that the repeater frequency is 800 kHz.

DEPR:
Now let us consider briefly the operation of the equipment of FIG. 4, 5, 6, 7, 8 and 9 when operating as a slave terminal. The slave terminal has the same circuits used in the master terminal for receiving the master sync burst and generating the received clock and doppler compensated transmit clock. In the case of the slave terminal, however, this doppler compensation is an open loop operation. It cannot correct for differences between the 1600 kHz. reference frequency at the master and slave stations, or for second order frequency errors in the repeater clock frequency. In addition, the initial phase of the transmit timer must be adjusted according to the range of the repeater from the slave stations.

DEPR:
The foregoing has been a brief summary of the operation of the equipment shown in FIGS. 4, 5, 6, 7, 8 and 9 for both a master station and a slave station.
The description will now proceed with a more detailed description of the various functional blocks of this equipment. As pointed out herein above the equipment of FIGS. 4, 5, 6, 7, 8 and 9 include all the equipment necessary to make the station operation as a master or slave station. In the master station the transmission of the master sync is enabled and the pseudo noise ranging signal is disabled. In the slave station the transmission of master sync is disabled and the pseudo noise ranging system is enabled.

DEPR:
The demodulated signal is used to lock a 6.4 MHz. voltage controlled oscillator 32 in the receive clock tracking phase locked loop 21. Since the 800 kHz. in the received sync burst contains the repeater to ground doppler, a clock is obtained which is proportional to the receive frame interval. The phase-locked loop 21 also serves as a narrow band filter for the incoming 800 kHz. sync signal. Included in receive clock tracking phase locked loop 21 is a set of correlators which measure the phase integrity of local receive frame referenced with the incoming sync and local frame clock. Phase-locked loop 21 will be described in further detail hereinbelow.

DEPR:
The station equipment of FIGS. 4, 5, 6, 7, 8, 9 will now be described more specifically. Referring to FIG. 4, the received IF signal coupled to distributor 30 which includes therein buffer amplifiers 41 and 42 to couple the IF signal to locked loop 20, buffer amplifier 43 to couple the IF signal to unit 31 which is not part of the synchronization system, and buffer amplifier 44 to couple the IF signal to the phase-locked loop 27 (FIG. 7). Phase-locked loop 20 locks to the sync burst received from the master station via the repeater by employing phase detector 45 coupled to the output of amplifier 41 and to the output of voltage controlled oscillator 46 through buffer amplifier 47. The error signal at the output of detector 45 is gated by sampling gate 48 during the 10 microsecond period that the sync burst is received, the gate signal being received from receive timer 22. This gate signal is normally a +3 volt signal which holds gate 48 open. During the sync burst, this gate signal goes to 0 and closes gate 48.

DEPR:
Referring to FIG. 6, the 800 kHz. +d output of receive timer 22

is coupled to transmit clock phase locked loop 19. Locked loop 19 compensates the transmit clock for first order doppler effects and the servo driven phase shifter 29 compensates for secondary clock errors. The doppler compensation circuit consists of a source of reference frequency 66, a mixer arrangement including mixers and filters 67, 68 and 69 to form a 1600 kHz. resultant signal at the output of mixer and filter 69 for application to phase detector 70 which receives its other input from source 66. It is necessary to avoid mixing the transmit and receive 800 kHz. clocks directly, otherwise, the sum frequency could not be distinguished from the second harmonics of the two input frequencies. The receive 800 kHz. is mixed with a 350 kHz. offset frequency signal from source 72 in mixer and filter 67 and the 450 kHz. difference signal is extracted. The transmit 800 kHz. signal from counter 33 is mixed with the offset frequency signal from source 72 in mixer and filter 68 and the 1150 kHz. sum frequency is extracted. The output signals from mixers and filters 67 and 68 are mixed in mixer and filter 69 to form the desired 1600 kHz. sum frequency. The output from detector 70 drives loop filter 71, which in turn, controls the voltage controlled oscillator 18. The output of oscillator 18 is divided by counter 33 to provide the transmit 800 kHz. -d. The receive 800 kHz. +d is from the repeater to this station only. Therefore, when the loop is locked the transmit clock will be doppler compensated.

DEPR:
The above description completes the description of the transmit phase locked loop 19 as it is used in master terminal. The motor-driven phase shifter 29 is inactive in the master station. However, this phase shifter 29 is used in a slave terminal as follows.

DEPR:
Referring to FIG. 7, there is illustrated therein the components forming
subcarrier tracking phase locked loop 27. This loop is used as a phase
demodulator for the pseudo noise ranging signal. The main difference between
this loop and the carrier tracking phase locked loop is that loop 27 is not
gated. The input to loop 27 is filtered at IF in band-pass filter and limiter
39 to remove the master sync signal and other data channel signals which are
received on the subcarrier frequency from the repeater. The band-pass filter
is followed by a limiter to remove amplitude variations caused by signal
suppression effects on the low level pseudo noise-ranging signal. The output
from filter and limiter 39 is coupled by means of buffer amplifier 40 to locked
loop 27 which includes phase detector 74 receiving one input from amplifier 40
and another input from voltage controlled oscillator 75. The output from
detector 74 which is the baseband signal is applied to baseband amplifier 76
and also to loop filter 77 to control oscillator 75. To provide the lock
detector, the output from amplifier 40 is coupled to phase detector 78 which
has its other input coupled to oscillator 75 through the 90.degree. phase
shifter 79. The output from phase detector 78 is coupled to subcarrier
tracking lock detector 80 to provide indication of when loop 27 is locked.

DEPR:
Referring to FIGS. 6 and 8, pseudo noise ranging phase locked loop 24 is
illustrated which is used to adjust the phase of the transmit timer (FIG. 9) in
a slave station during initial acquisition. The correct phase is determined by
comparing the time at which the slave station's pseudo noise-ranging signal is
received from the repeater against time the master sync burst is received from
the repeater. To facilitate this comparison, a reference pseudo noise signal

is generated by generator 28 in response to receive timer 22 (FIG. 5) which itself is locked in time to the received master sync burst.

DEPR:
The carrier-tracking phase-locked loop 20 (FIG. 4) and receive timer 22 (FIG. 5) operate from the sync burst received via the repeater from the master terminal. The pseudo noise reference signal at the output of generator 28 can then be assumed to be fixed in time as far as the slave terminal is concerned.

DEPR:
The purpose of locked loop 24 is to correct the initial phase of the slave stations transmit timer 17. This is actually accomplished in three modes. The first two modes are a digital advance or retard of transmit timer 17. The third mode is a phase correction by motor driven phase shifter 29 which operates on the 6.4 MHz. output of oscillator 18 (FIG. 6). The three modes in the acquisition procedure are: (1) coarse slew is a search in which the phase of transmit timer 17 is advanced in steps on the order of 5 microseconds until pseudo noise lock occurs; (2) fine slew wherein transmit timer 17 is digitally advanced or retarded in steps on the order of 0.5 microseconds depending on whether the received pseudo noise signal is early or late; and (3) maintenance where a fine phase adjustment is obtained by means of phase shifter 29 according to the output of the pseudo noise error detector including multiplier 81, loop filter 82 and motor amplifier 83.

DEPR:
In a master station, the receive status register will automatically go from receive mode 0 to receive mode 1 when in transmit mode 1. The transmit modes will be discussed hereinbelow.

DEPR:
The counter states of counter 147 are decoded by matrix 149 to provide the

element time slots ELM00 to ELM08. The binary states of counter 147 are decoded by matrix 150 to provide the burst interval timing signals BST00 to BST10. The timing signals in the outputs of matrixes 149 and 150 are available for other system functions for transmit time interval gating. The transmit timer counters for four control times, two for fine slewing and two for coarse slewing of the transmit frame cycle phase. These are generated in the transmit timer slew control unit including decoder slew command unit 151 slew signal generator 152, slew inhibit generator 153 and slew signal width control unit 154.

DEPR:
Transmit mode control unit 159 is similar to the receive mode control unit. It consists of an eight state memory where each state signifies the status to the transmit synchronization process. At present, only the first four states are used and these are assigned as follows. For a master terminal, state 0 corresponds to transmit mode 0 which provides the action of automatic carrier control and automatic sync modulator control, transmit carrier CW and transmit 800 kHz. CW. State 1 corresponds to transmit mode 1 which permits automatic carrier control and automatic sync modulator control, transmit carrier pulsed and 800 kHz. pulsed. States 2 and 3 correspond to transmit modes 2 and 3 which are not used in the master station. For a slave terminal, state 0 represents transmit mode 0 and is inactive and is utilized as the reset state.
State 1 corresponds to transmit mode 1 which enables coarse slew step function.
State 2 corresponds to transmit mode 2 which enables fine slew step function.
State 3 corresponds to transmit mode 3. In this state the servo drive is enabled and also the fill burst transmission is enabled. This is the normal operating mode of the slave station.

CLPR:
1. A synchronization system to control signals transmitted from each of a
master station and a plurality of slave stations to be propagated through a
common repeater in a different one of a plurality of time slots of time
division multiplex format as said repeater, said stations and said repeater
having relative motion therebetween, comprising:

CLPR:
2. A system according to claim 1, further including a source of said ranging
signal in each of said slave stations, said ranging signal source including

CLPR:
13. A system according to claim 12 further including a source of said ranging
signal in each of said slave stations, said ranging signal source including
pseudo noise code signal, means for detecting the pseudo noise code signal in
the ranging signal received a t the slave station, means for comparing the
transmitted and detected pseudo noise code signals for deriving first and
second signals respectively indicative of lock between the detected and
transmitted pseudo noise signal and the relative time positions of the detected
and transmitted pseudo noise signal, and means for controlling said first and
second means in response to the first and second signals respectively.

CLPR:
14. A synchronization system to control signals transmitted from each of a
master station and a plurality of slave stations to be propagated through a
common repeater in a different one of a plurality of time slots of a time
division multiplex format at said repeater, said stations and said repeater
having relative motion therebetween comprising:

CLPV:
first means disposed in said master station to transmit a sync burst through

said repeater in one of said time slots;

CLPV:
second means disposed in each of said slave stations responsive to said sync
burst from said repeater to control the production of timing signals employed
to control the time of transmission of said transmitted signals from the
associated one of said slave stations;

CLPV:
third means disposed in each of said slave stations to transmit a ranging
signal through said repeater in its associated one of said time slots; means
disposed in each of the slave stations for receiving the ranging signal
transmitted by the associated slave station through the repeater; and

CLPV:
means, including digital and analog signal processing means, disposed in each
of said slave stations coupled to said second means responsive to said ranging
signal received from said repeater to adjust the time position of said timing
signals so that the time of transmission of said transmitted signals from the
associated one of said slave stations is such that said transmitted signals
occurs in the proper one of said time slots at said repeater.

CLPV:
compensate for the doppler effect in the transmission path from said master
station to said repeater to provide said sync burst received at said repeater
with the desired carrier frequency.

CLPV:
first means disposed in said master station to transmit a sync burst through
said repeater in one of said time slots:

CLPV:
second means disposed in each of said slave stations responsive to said sync
burst from said repeater to control the production of timing signals employed

to control the time of transmission of said transmitted signals from the
associated one of said slave stations;

CLPV:
third means disposed in each of said slave stations to transmit a ranging
signal through said repeater in its associated one of said time slots; means
disposed in each of the slave stations for receiving the ranging signal
transmitted by the associated slave station through the repeater; and means
disposed in each of said slave stations coupled to said second means responsive
to said ranging signal received from said repeater to adjust the time position
of said timing signals so that the time of transmission of said transmitted
signals from the associated one of said slave stations is such that said
transmitted signal occurs in the proper one of said time slots at said repeater
and said time position-adjusting means including: counter means, a variable
phase source of oscillations driving the counter means, means in response to
the ranging signal and independently of the oscillations, and means for
controlling the phase of the oscillations in response to the ranging signal,
the slew-adjustment of the counter means and the phase adjustment of the
oscillations respectively being relatively coarse and fine controls for time of
transmission of the transmitted signals.

CLPW:
fifth means to receive said sync burst from said repeater, and

CLPW:
fourth means to receive said ranging signal from said repeater,

CLPW:
fourth means to adjust the carrier frequency of said transmitted signals to
compensate for the doppler effect in the transmission path from the associated
one of said slave stations to said repeater to provide said transmitted signal
received at said repeater with the desired carrier frequency.

CLPW:
fifth means to receive said sync burst from said repeater, and

CLPW:
from said repeater, a source of reference ranging signal, eighth
means
responsive to said source of reference ranging

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Total	**0**	**19**	**0**

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ABPL:

A master station and a plurality of slave stations include synchronization equipment to enable each of the stations to have access to a common repeater in a different time slot of a time division multiplex format at the repeater, there being motion between the stations and the repeater. The master station propagates a sync burst through the repeater. Each of the stations receives this sync burst from the repeater and adjusts the frequency of the timing signals therein to compensate for the doppler shift experienced in the propagation path from each of the stations to the repeater so that the desired frequency of the timing signals is present in the repeater. Each of the slave stations also propagates different low power level, psuedo noise code ranging signal through the repeater back to itself which is used to adjust the phase of the timing signals digitally and in an analog manner by means of a motor-driven phase shifter to account for the changing range between the repeater and each of the slave stations so that a data burst of each of the slave stations appears in the proper time slot of the time division multiplex format at the repeater.

BSPR:

This invention relates to communication systems and more particularly to communications systems wherein a plurality of stations gain access to and communicate through a common propagation media, such as a common repeater.

BSPR:

Multiple access communication systems have been utilized for many years to achieve multiple access to long-distance telephone trunk systems. In addition, this multiple access technique is applicable to other communication systems including, but not necessarily restricted thereto, (1) supervisory control systems to enable supervision, from a fixed common repeater, or from a central station through the common repeater, of the activities of a plurality of mobile stations, (2) remote control systems to enable control, from a fixed common repeater, or from a central station through the common repeater, of various responsive devices contained in a plurality of mobile stations, (3) communication systems to establish, maintain and/or enable communication between a fixed common repeater, or a communication center coupled to the fixed common repeater, and a plurality of mobile stations, such as is necessary between an airport control tower and a plurality of airliners, and between a dispatcher communication center and a fleet of taxicabs, emergency vehicles and cargo carrying trucks, and (4) a communication satellite system to enable a plurality of fixed ground stations to utilize a common repeater carried by an orbiting satellite.

BSPR:
In providing the multiple access for the various systems above set forth, different techniques have been employed in the past. One such technique is the so called random access technique to enable a plurality of stations to have access to and communicate through a common repeater on an undefined basis, namely, a random basis. Another such technique to permit achieving of multiple access is in the employment of frequency division multiplex techniques wherein each of the plurality of stations employs a different carrier signal and wherein the common repeater has the bandwidth to handle all of the different

frequency carriers and the intelligence carried thereon. Still another technique enabling multiple access to a common repeater has been by the employment of time division multiplex techniques wherein each of the plurality of stations are assigned to, or are capable of selecting, a time slot in time division multiplex frame or format at the common repeater to thereby permit communication through the common repeater in a noninterferring relationship.

BSPR:
In multiple access systems employing time division multiplex techniques it is mandatory that there be a strict time synchronization so that each of the plurality of stations transmits its intelligence in a different one of a plurality of time slots of a time division multiplex format and be so confined to that time slot selected for a particular station that its communication will not interfere with communications of other stations in adjacent time slots of the format.

BSPR:
In time division multiplex multiple access systems, it has in the past been the practice for a common repeater to receive a number of independent carrier signals and by commutation equipment carried in the repeater interleave the independent carrier signals bit by bit in a continuous sequence. This arrangement requires considerable equipment in the repeater. If the repeater is mobile, such as in satellite communication systems and the like, there could result a weight problem for the vehicle carrying the repeater equipment and with respect to a satellite carrying the repeater equipment an increase in the cost of the launch vehicle to place the satellite in a desired orbit.

BSPR:
In a prior art time division multiplex multiple access system, such as

described in U.S. Pat. No. 3,320,611 and Belgium Pat. No. 669,318, there is described an arrangement enabling a reduction in the hardware required in the repeater and, hence, a reduction in the problem of providing a vehicle to carry this repeater. By removing the time division multiplex equipment from the repeater itself it is possible to use a simple clipper/amplifier or hard limiting repeater.

BSPR:
It has been found, in addition, that the pulse or bit-by-bit interleaving imposes considerable equipment problems in the plurality of stations requiring access to the common repeater. This complexity can be overcome, or at least materially reduced where the interleaving at the repeater is performed on bursts of pulses from each station.

BSPR:
Where there is relative movement between the common repeater and the plurality of stations, whether it is the repeater that is moving, or the stations that are moving, or both the repeater and stations moving relative to each other, it is necessary, where time division multiplex techniques for multiple access to the common repeater are employed, to provide in some manner the range information between the station considered and the common repeater on a continuous basis. In the above-cited prior art patents, this range information was obtained from a computer or like device contained in each of the plurality of stations which provide information of the relative location of and range between the common station and the considered one of the plurality of stations with the programming of the computer being based upon predicted relative movement between the common repeater and the considered station. The total inaccuracy of the range prediction with elementary equipment has been determined to be in the order of one microsecond. Hence, the

system timing
format was developed having a one microsecond guard band between transmission
from each station and the next adjacent station in the format. To realize
reasonable efficiency of utilization of the common repeater, each station burst
interval must be long in comparison to this guard band, hence, a burst length
of 125 microseconds was established. Thus, each station must have equipment to
store communication traffic for a short period of time and transmit this in a
125 microsecond burst. The repetition interval and, consequently, the required
storage time is the product of burst length and the number of simultaneous
users for which the multiple access system has been designed.

BSPR:
In a known prior art arrangement, the continuous range information is provided
by means of a pseudo noise code signal transmitted from each of the stations
through the repeater back to itself with the equipment responding to this
pseudo noise code signal to adjust the timing signals to account for changing
range between the station and the repeater with the control of the timing
signals being performed in a digital manner.

BSPR:
Another object of the present invention is to provide a synchronizing system
for a time division multiplex multiple access system wherein the
synchronization equipment is located in each of a plurality of slave stations
and a master station with the common repeater being of the hard limiter
repeater.

BSPR:
Still another object of this invention is to provide a synchronizing system for
a time division multiplex multiple access system that does not require knowing
or predicting the position of the considered station and the common repeater
and the range between the considered station and the common repeater.

BSPR:
Still a further object of this invention is to provide a combined digital and
analog synchronizing system for a time division multiplex multiple access
system incorporating therein an arrangement to compensate for the doppler shift
of the transmission path from the considered station to the common repeater.

BSPR:
A feature of this invention is the provision of a synchronization system to
control signals transmitted from each of a master station and a plurality of
slave stations to be propagated through a common repeater in a different one of
a plurality of time slots of time division multiplex format at the repeater,
the stations and the repeater having relative motion therebetween, comprising
first means disposed in the master station to transmit a sync burst through the
repeater in one of the time slots; second means disposed in each of the slave
stations responsive to the sync burst from the repeater to control the
production of timing signals employed to control the time of transmission of
the transmitted signals from the associated one of the slave stations; third
means disposed in each of the slave stations to transmit a ranging signal
through the repeater in its associated one of the time slots; and combined
digital and analog means disposed in each of the slave stations coupled to the
second means responsive to the ranging signal received from the repeater to
adjust the phase of the timing signals so that the time of transmission of the
transmitted signals from the associated one of the slave stations is such that
the transmitted signals occur in the proper one of the time slots at the
repeater.

BSPR:
Another feature of this invention is the provision of means in each of the

above-mentioned first means and second means to adjust the frequency of the
synch burst and the frequency of the transmitted signal to compensate for the
doppler effect in the transmission path from the master station to the repeater
and in the transmission path from the associated one of the slave stations to
the repeater to provide the sync burst and the transmitted signal received at
the repeater with the desired frequency.

DRPR:
FIG. 2 is a timing diagram illustrating the frame format of the time division
multiplex frame at the common repeater of FIG. 1;

DEPR:
Referring to FIG. 1, there is illustrated therein a block diagram of a
generalized multiple access communication system wherein a plurality of
stations, which for purposes of illustration and explanation are assumed to be
master station 11 and slave stations 1 to 10, are shown in two-way
communication with common repeater 12. As indicated, common repeater 12 can be
fixed or mobile and each of stations 1 through 11 can be fixed or mobile. It
should be noted that the multiple access system of FIG. 1 can be used in any of
the applications outlined hereinabove under the heading "Background of the
Invention." While this multiple access system can employ frequency division
multiplex or random access techniques for multiple access, in accordance with
the principles of this invention it is intended that multiple access be
provided to repeater 12 by employing time division multiplex techniques.

DEPR:
In the multiple access communication system each of the stations 1 through 11
transmits bursts which are timed to arrive at the repeater 12 on a
noninterferring relation relative to bursts from other stations. The phasing
of the transmitted signals must then be adjusted to compensate

for the
difference in range between repeater 12 and the various stations 1 to 11.
Where there is motion between repeater 12 and stations 1 and 11, the range is
continuously changing and the continuous phase adjustment results in a
frequency offset, namely, the doppler effect which is proportional to the rate
of change of range.

DEPR:
The time division multiplex format for the system of this invention is shown in
curve C, FIG. 2, and is based on the real time transmission of information. A
single sync burst, as illustrated in Curve A, FIG. 2, is transmitted from the
master station and 10 data bursts of 10 microseconds duration are transmitted
from slave stations 1 through 10. Curve B, FIG. 2, illustrates the data bursts
transmitted from slave station 1. As illustrated in Curve C, FIG. 2, the frame
format at repeater 12 includes the sync burst and data bursts each having a 10
microsecond duration with a 1.25 microsecond guard time therebetween resulting
in a frame period of 123.75 microseconds.

DEPR:
Synchronization is maintained by doppler tracking in which master station 11
tracks the doppler actively and slave stations 1 to 10 track the doppler
passively. The sync burst carrier is modulated by 800 kHz. (kilohertz) which
is harmonically related to the frame rate and is used for all time divisions in
the format. Master station 11 transmits the sync burst consisting of 800 kHz.
minus its own doppler and receives the sync burst as 800 kHz. plus its own
doppler. The transmitted frequency is adjusted so that sum of the transmitted
and received frequencies is a constant. This method of doppler tracking
assures that the sync signal at the repeater 12 is true 800 kHz.

DEPR:
A slave station receives the pulsed sync burst from master

station 11 via
repeater 12. Since the signal was a true 800 kHz. at repeater 12, it will be
received with the true doppler of the considered slave station. The slave
station uses this signal to preset its transmit frame rate by a technique
identical to that used by master station 11 for doppler tracking. The slave
stations used in pseudo noise code ranging technique to determine the correct
initial phase for their transmit format.

DEPR:
The equipment employed in each of the master station 11 and slave stations 1
through 10 is illustrated in block diagram form in FIGS. 4, 5, 6, 7, 8 and 9,
when arranged as illustrated in FIG. 3. By proper manipulation of switches
A4S59, A4S53, A4S56, A4S46, and A4S43 (FIG. 9), it is possible to have the
equipment operate as a master station wherein the pseudo noise and subcarrier
operation is inhibited and the sync burst and carrier operation are activated.
To provide operation as a slave station, the sync burst modulation and carrier
are inhibited and the pseudo noise modulation and subcarrier are activated.

DEPR:
The transmit clock generator, identified as transmit clock phase locked loop
19, contains the doppler compensation circuit which adjusts the transmitted
clock frequency to maintain the repeater clock frequencies at exactly 800 kHz.
independent of first order doppler effects. This is implemented by passing the
receive and transmit clock frequencies through a mixer arrangement which
extracts their sum frequency, then compares the sum frequency with a 1600 kHz.
reference frequency and adjusts the phase of the voltage controlled oscillator
18 in such a manner to keep the sum exactly equal to 1600 kHz.

DEPR:
Letting fR and fT denote the receive and transmit frequencies, respectively,

this may be written as fR+fT=1600. Assuming that fT is decreased by the doppler coefficient d in transmission, the repeater frequency will be frep. = fT-d. Ignoring second order effects, the receive frequency will be equal to the repeater frequency reduced by d, namely, fR = frep. - d. Substituting the last two equations into the first equation will demonstrate that the repeater frequency is 800 kHz.

DEPR:
Now let us consider briefly the operation of the equipment of FIG. 4, 5, 6, 7, 8 and 9 when operating as a slave terminal. The slave terminal has the same circuits used in the master terminal for receiving the master sync burst and generating the received clock and doppler compensated transmit clock. In the case of the slave terminal, however, this doppler compensation is an open loop operation. It cannot correct for differences between the 1600 kHz. reference frequency at the master and slave stations, or for second order frequency errors in the repeater clock frequency. In addition, the initial phase of the transmit timer must be adjusted according to the range of the repeater from the slave stations.

DEPR:
The foregoing has been a brief summary of the operation of the equipment shown in FIGS. 4, 5, 6, 7, 8 and 9 for both a master station and a slave station. The description will now proceed with a more detailed description of the various functional blocks of this equipment. As pointed out herein above the equipment of FIGS. 4, 5, 6, 7, 8 and 9 include all the equipment necessary to make the station operation as a master or slave station. In the master station the transmission of the master sync is enabled and the pseudo noise ranging signal is disabled. In the slave station the transmission of master sync is disabled and the pseudo noise ranging system is enabled.

DEPR:
The demodulated signal is used to lock a 6.4 MHz. voltage controlled oscillator 32 in the receive clock tracking phase locked loop 21. Since the 800 kHz. in the received sync burst contains the repeater to ground doppler, a clock is obtained which is proportional to the receive frame interval. The phase-locked loop 21 also serves as a narrow band filter for the incoming 800 kHz. sync signal. Included in receive clock tracking phase locked loop 21 is a set of correlators which measure the phase integrity of local receive frame referenced with the incoming sync and local frame clock. Phase-locked loop 21 will be described in further detail hereinbelow.

DEPR:
The station equipment of FIGS. 4, 5, 6, 7, 8, 9 will now be described more specifically. Referring to FIG. 4, the received IF signal coupled to distributor 30 which includes therein buffer amplifiers 41 and 42 to couple the IF signal to locked loop 20, buffer amplifier 43 to couple the IF signal to unit 31 which is not part of the synchronization system, and buffer amplifier 44 to couple the IF signal to the phase-locked loop 27 (FIG. 7). Phase-locked loop 20 locks to the sync burst received from the master station via the repeater by employing phase detector 45 coupled to the output of amplifier 41 and to the output of voltage controlled oscillator 46 through buffer amplifier 47. The error signal at the output of detector 45 is gated by sampling gate 48 during the 10 microsecond period that the sync burst is received, the gate signal being received from receive timer 22. This gate signal is normally a +3 volt signal which holds gate 48 open. During the sync burst, this gate signal goes to 0 and closes gate 48.

DEPR:
Referring to FIG. 6, the 800 kHz. +d output of receive timer 22

is coupled to transmit clock phase locked loop 19. Locked loop 19 compensates the transmit clock for first order doppler effects and the servo driven phase shifter 29 compensates for secondary clock errors. The doppler compensation circuit consists of a source of reference frequency 66, a mixer arrangement including mixers and filters 67, 68 and 69 to form a 1600 kHz. resultant signal at the output of mixer and filter 69 for application to phase detector 70 which receives its other input from source 66. It is necessary to avoid mixing the transmit and receive 800 kHz. clocks directly, otherwise, the sum frequency could not be distinguished from the second harmonics of the two input frequencies. The receive 800 kHz. is mixed with a 350 kHz. offset frequency signal from source 72 in mixer and filter 67 and the 450 kHz. difference signal is extracted. The transmit 800 kHz. signal from counter 33 is mixed with the offset frequency signal from source 72 in mixer and filter 68 and the 1150 kHz. sum frequency is extracted. The output signals from mixers and filters 67 and 68 are mixed in mixer and filter 69 to form the desired 1600 kHz. sum frequency. The output from detector 70 drives loop filter 71, which in turn, controls the voltage controlled oscillator 18. The output of oscillator 18 is divided by counter 33 to provide the transmit 800 kHz. -d.
The receive 800 kHz. +d is from the repeater to this station only. Therefore, when the loop is locked the transmit clock will be doppler compensated.

DEPR:
The above description completes the description of the transmit phase locked loop 19 as it is used in master terminal. The motor-driven phase shifter 29 is inactive in the master station. However, this phase shifter 29 is used in a slave terminal as follows.

DEPR:
Referring to FIG. 7, there is illustrated therein the components forming subcarrier tracking phase locked loop 27. This loop is used as a phase demodulator for the pseudo noise ranging signal. The main difference between this loop and the carrier tracking phase locked loop is that loop 27 is not gated. The input to loop 27 is filtered at IF in band-pass filter and limiter 39 to remove the master sync signal and other data channel signals which are received on the subcarrier frequency from the repeater. The band-pass filter is followed by a limiter to remove amplitude variations caused by signal suppression effects on the low level pseudo noise-ranging signal. The output from filter and limiter 39 is coupled by means of buffer amplifier 40 to locked loop 27 which includes phase detector 74 receiving one input from amplifier 40 and another input from voltage controlled oscillator 75. The output from detector 74 which is the baseband signal is applied to baseband amplifier 76 and also to loop filter 77 to control oscillator 75. To provide the lock detector, the output from amplifier 40 is coupled to phase detector 78 which has its other input coupled to oscillator 75 through the 90.degree. phase shifter 79. The output from phase detector 78 is coupled to subcarrier tracking lock detector 80 to provide indication of when loop 27 is locked.

DEPR:
Referring to FIGS. 6 and 8, pseudo noise ranging phase locked loop 24 is illustrated which is used to adjust the phase of the transmit timer (FIG. 9) in a slave station during initial acquisition. The correct phase is determined by comparing the time at which the slave station's pseudo noise-ranging signal is received from the repeater against time the master sync burst is received from the repeater. To facilitate this comparison, a reference pseudo noise signal

is generated by generator 28 in response to receive timer 22 (FIG. 5) which itself is locked in time to the received master sync burst.

DEPR:
The carrier-tracking phase-locked loop 20 (FIG. 4) and receive timer 22 (FIG. 5) operate from the sync burst received via the repeater from the master terminal. The pseudo noise reference signal at the output of generator 28 can then be assumed to be fixed in time as far as the slave terminal is concerned.

DEPR:
The purpose of locked loop 24 is to correct the initial phase of the slave stations transmit timer 17. This is actually accomplished in three modes. The first two modes are a digital advance or retard of transmit timer 17. The third mode is a phase correction by motor driven phase shifter 29 which operates on the 6.4 MHz. output of oscillator 18 (FIG. 6). The three modes in the acquisition procedure are: (1) coarse slew is a search in which the phase of transmit timer 17 is advanced in steps on the order of 5 microseconds until pseudo noise lock occurs; (2) fine slew wherein transmit timer 17 is digitally advanced or retarded in steps on the order of 0.5 microseconds depending on whether the received pseudo noise signal is early or late; and (3) maintenance where a fine phase adjustment is obtained by means of phase shifter 29 according to the output of the pseudo noise error detector including multiplier 81, loop filter 82 and motor amplifier 83.

DEPR:
In a master station, the receive status register will automatically go from receive mode 0 to receive mode 1 when in transmit mode 1. The transmit modes will be discussed hereinbelow.

DEPR:
The counter states of counter 147 are decoded by matrix 149 to provide the

element time slots ELM00 to ELM08. The binary states of counter 147 are decoded by matrix 150 to provide the burst interval timing signals BST00 to BST10. The timing signals in the outputs of matrixes 149 and 150 are available for other system functions for transmit time interval gating. The transmit timer counters for four control times, two for fine slewing and two for coarse slewing of the transmit frame cycle phase. These are generated in the transmit timer slew control unit including decoder slew command unit 151 slew signal generator 152, slew inhibit generator 153 and slew signal width control unit 154.

DEPR:
Transmit mode control unit 159 is similar to the receive mode control unit. It consists of an eight state memory where each state signifies the status to the transmit synchronization process. At present, only the first four states are used and these are assigned as follows. For a master terminal, state 0 corresponds to transmit mode 0 which provides the action of automatic carrier control and automatic sync modulator control, transmit carrier CW and transmit 800 kHz. CW. State 1 corresponds to transmit mode 1 which permits automatic carrier control and automatic sync modulator control, transmit carrier pulsed and 800 kHz. pulsed. States 2 and 3 correspond to transmit modes 2 and 3 which are not used in the master station. For a slave terminal, state 0 represents transmit mode 0 and is inactive and is utilized as the reset state.
State 1 corresponds to transmit mode 1 which enables coarse slew step function.
State 2 corresponds to transmit mode 2 which enables fine slew step function.
State 3 corresponds to transmit mode 3. In this state the servo drive is enabled and also the fill burst transmission is enabled. This is the normal operating mode of the slave station.

CLPR:
1. A synchronization system to control signals transmitted from each of a
master station and a plurality of slave stations to be propagated through a
common repeater in a different one of a plurality of time slots of time
division multiplex format as said repeater, said stations and said repeater
having relative motion therebetween, comprising:

CLPR:
2. A system according to claim 1, further including a source of said ranging
signal in each of said slave stations, said ranging signal source including

CLPR:
13. A system according to claim 12 further including a source of said ranging
signal in each of said slave stations, said ranging signal source including
pseudo noise code signal, means for detecting the pseudo noise code signal in
the ranging signal received a t the slave station, means for comparing the
transmitted and detected pseudo noise code signals for deriving first and
second signals respectively indicative of lock between the detected and
transmitted pseudo noise signal and the relative time positions of the detected
and transmitted pseudo noise signal, and means for controlling said first and
second means in response to the first and second signals respectively.

CLPR:
14. A synchronization system to control signals transmitted from each of a
master station and a plurality of slave stations to be propagated through a
common repeater in a different one of a plurality of time slots of a time
division multiplex format at said repeater, said stations and said repeater
having relative motion therebetween comprising:

CLPV:
first means disposed in said master station to transmit a sync burst through

said repeater in one of said time slots;

CLPV:
second means disposed in each of said slave stations responsive to said sync
burst from said repeater to control the production of timing signals employed
to control the time of transmission of said transmitted signals from the
associated one of said slave stations;

CLPV:
third means disposed in each of said slave stations to transmit a ranging
signal through said repeater in its associated one of said time slots; means
disposed in each of the slave stations for receiving the ranging signal
transmitted by the associated slave station through the repeater; and

CLPV:
means, including digital and analog signal processing means, disposed in each
of said slave stations coupled to said second means responsive to said ranging
signal received from said repeater to adjust the time position of said timing
signals so that the time of transmission of said transmitted signals from the
associated one of said slave stations is such that said transmitted signals
occurs in the proper one of said time slots at said repeater.

CLPV:
compensate for the doppler effect in the transmission path from said master
station to said repeater to provide said sync burst received at said repeater
with the desired carrier frequency.

CLPV:
first means disposed in said master station to transmit a sync burst through
said repeater in one of said time slots:

CLPV:
second means disposed in each of said slave stations responsive to said sync
burst from said repeater to control the production of timing signals employed

to control the time of transmission of said transmitted signals from the associated one of said slave stations;

CLPV:
third means disposed in each of said slave stations to transmit a ranging signal through said repeater in its associated one of said time slots; means disposed in each of the slave stations for receiving the ranging signal transmitted by the associated slave station through the repeater; and means disposed in each of said slave stations coupled to said second means responsive to said ranging signal received from said repeater to adjust the time position of said timing signals so that the time of transmission of said transmitted signals from the associated one of said slave stations is such that said transmitted signal occurs in the proper one of said time slots at said repeater and said time position-adjusting means including: counter means, a variable phase source of oscillations driving the counter means, means in response to the ranging signal and independently of the oscillations, and means for controlling the phase of the oscillations in response to the ranging signal, the slew-adjustment of the counter means and the phase adjustment of the oscillations respectively being relatively coarse and fine controls for time of transmission of the transmitted signals.

CLPW:
fifth means to receive said sync burst from said repeater, and

CLPW:
fourth means to receive said ranging signal from said repeater,

CLPW:
fourth means to adjust the carrier frequency of said transmitted signals to compensate for the doppler effect in the transmission path from the associated one of said slave stations to said repeater to provide said transmitted signal received at said repeater with the desired carrier frequency.

CLPW:
fifth means to receive said sync burst from said repeater, and

CLPW:
from said repeater, a source of reference ranging signal, eighth
means
responsive to said source of reference ranging

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	☐	Document ID	Issue Date	Title
1	☒	US 3593138 A	19710713	SATELLITE INTERLACE SYNCHRONIZATION SYSTEM
2	☒	US 4549293 A	19851022	Time division multiple access communications system
3	☒	US 4577315 A	19860318	Power saving system for time-division multiple access radiocommunication network
4	☐	US 3742498 A	19730626	SYNCHRONIZATION AND POSITION LOCATION SYSTEM
5	☐	US 3742498 A	19730626	SYNCHRONIZATION AND POSITION LOCATION SYSTEM
6	☐	US 4252999 A	19810224	Signaling and ranging technique for a TDMA satellite communication system
7	☐	US 4547879 A	19851015	Digital data transmission process and installation

	Current OR	Current XRef
1	375/211	342/88 ; 375/285 ; 375/368 ; 455/11.1
2	370/347	370/327 ; 455/517
3	370/311	340/825.44 ; 370/347 ; 455/343 ; 455/38.3 ; 455/528 ; 455/68 ; 455/70
4		
5	342/88	342/103 ; 342/126 ; 342/357.01 ; 342/50 ; 370/508 ; 370/515 ; 455/13.1 ; 455/13.2
6	370/323	
7	370/438	

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	L #	Hits	Search Text	Time Stamp
1	L1	0	(repeater) and (slave units) and (master or base) and @pn<1987	2000/07/20 16:20
2	L2	0	(repeater) and (slave) and (master or base) and @pn<1987	2000/07/20 16:21
3	L3	726	(repeater) and (time adj slots)	2000/07/20 16:25
4	L4	220	(repeater) and (time adj slots) and @py<1988	2000/07/20 16:28
5	L5	7	4 and ((slave adj units) or (slave adj stations)) and ((master adj unit) or (master adj station$))	2000/07/20 16:34